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Development of sucking patterns in preterm infants

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5 The maturation of sucking patterns in preterm, small- for-gestational age infants

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Abstract

Objective To determine whether the development of sucking patterns in small-for-gestational age (SGA) preterm infants is different from appropriate-for-gestational age (AGA) preterm infants.

Study Design We studied sucking patterns of 15 SGA and 34 AGA preterms (gestational age ≤ 36 weeks) longitudinally from 34 to 50 weeks postmenstrual age (PMA) with the Neonatal Oral-Motor Assessment Scale (NOMAS). We diagnosed them as normal, dysfunctional, or disorganised. We examined the course of sucking patterns in relation to clinical characteristics.

Results SGA preterms developed a normal sucking pattern later than AGA preterms (median 48 versus 42 weeks PMA, $p=.002$). At term equivalent age, none of the SGA and 38% of the AGA preterms showed normal sucking ($p<.05$); this was 54% and 81% at 48-50 weeks PMA ($p=.064$). Abnormal clusters including 'incoordination' and dysfunctional sucking were more prevalent in SGA preterms than in AGA preterms (median 11% of measurements per child, versus 0%, $p<.05$). A higher gestational age and standard deviation score for birth weight were predictive of normal sucking at 50 weeks PMA.

Conclusions SGA preterms developed a normal sucking pattern later than AGA preterms. AGA preterms also needed time till after they had reached term age to develop a normal sucking pattern.

For nourishment newborn infants rely heavily on their ability to suck and swallow liquids effectively. Characteristic of the development of sucking and swallowing in healthy, fullterm infants is an increase in the rate of sucking and swallowing, longer sucking bursts, and larger volumes per suck with increasing post-menstrual age (PMA) ¹⁻⁴.

Preterm infants, and small-for-gestational age (SGA) preterm infants in particular, are at increased risk for impaired sucking and swallowing. They have two disadvantages: prematurity and increased nutritional needs for catch-up growth. Both factors may affect the development of their sucking patterns. During the neonatal period, the neurobehavioral organization of SGA preterm infants is poorer compared to that of their appropriate-for-gestational age matched peers. This is expressed in instable state organization, poor motor maturity, and lower orientation to social and non-social stimuli ⁵. During follow-up, former SGA preterm children are at increased risk for subtle motor, cognitive, and behavioural developmental deficits later on ⁶. Feeding disorders are also more prevalent in these children ⁷. In a study on a cohort of 465 children under the age of ten years, that had been referred to a multidisciplinary eating disorder clinic in Belgium, they found that children with feeding disorders had significantly lower birth weights for gestational age ⁷. Especially feeding disorders caused by gastrointestinal or neurological pathology were related to lower birth weights for gestational age. Therefore, deviant development of sucking and swallowing might be the basis of persistent feeding problems in former SGA preterm children ⁷.

It is unknown, however, whether the development of sucking and swallowing is impaired in SGA preterm infants. The Neonatal Oral-Motor Assessment Scale (NOMAS) ⁸ is a method that could help to investigate sucking patterns in young infants up to the age of several months post-term. It is a standardised, non-invasive tool that can be used to assess both breastfeeding and bottle-feeding. Inter-rater and intra-rater reliabilities are fair ⁹. Of all the available non-invasive tools, it emerged as the best tool for assessing sucking patterns in young infants ¹⁰. It sets standards for normal and abnormal (disorganised and dysfunctional) sucking patterns. Recently, the typical development of sucking patterns from birth to 10 weeks post-term was investigated in healthy fullterm infants using this assessment method ¹¹. To date, the NOMAS has not been used longitudinally in a study of SGA preterm infants. The aim of our study was, therefore, to investigate the development of sucking patterns from birth to 10 weeks post-term in SGA preterm infants and to compare this with a group of appropriate-for-gestational age (AGA) preterm infants. We hypothesised that SGA preterm infants would develop a normal sucking pattern later, would need to rely

on tube-feeding longer, and would be hindered by a dysfunctional sucking pattern more often than AGA preterm infants. In particular, we expected that this group of infants would have more difficulty initiating sucking movements and that sucking and swallowing would be arrhythmical as a result of their poor state organization. Moreover, abnormal jaw and tongue movements, as a component of the poor motor maturity of these infants, would probably interrupt effective sucking movements.

Methods

Subjects

This was a prospective, longitudinal study. We enrolled 15 SGA preterm infants (birth weight below the tenth percentile) and 34 appropriate-for-gestational age preterm infants. The infants had been admitted to the Neonatal Intensive Care Unit of the University Medical Center of Groningen Hospital and the neonatal ward of the Martini Hospital, also in Groningen, the Netherlands. The criterion for inclusion was a gestational age below 36 weeks PMA. Infants with major congenital defects and syndromes (such as e.g. esophageal atresia and Down's syndrome), and infants that had been exposed to substance or alcohol abuse while in utero, were excluded. During the study we excluded infants who developed necrotising enterocolitis. We collected several demographic perinatal and neonatal clinical data such as birth type (whether vaginal birth or caesarean section), gender, birth weight characteristics, including the standard deviation (SD) score of birth weight in relation to gestational age, the Apgar scores at 1 and 5 minutes, need for ventilatory support, presence of bronchopulmonary dysplasia (BPD, defined as oxygen dependency at 36 weeks post menstrual age), presence of brain lesions on ultrasound scans, and the Nursery Neurobiologic Risk Score 12 (Table 1, online). This test was administered at discharge around term equivalent age. Brain lesions were determined from serial, weekly ultrasound scans and scored in both groups. Germinal matrix haemorrhages (GMH) were classified according to Volpe 13 and periventricular leukomalacia was classified according to De Vries et al 14.

The study commenced after permission was granted by the medical and ethical review committee of the University Hospital of Groningen, and after written informed parental consent had been obtained.

Recording of sucking patterns

The NOMAS was assessed from video-taped recordings. The infants were recorded as soon as possible, following parental consent after they had started feeding orally, i.e. from 34 weeks PMA, at the earliest. The decision to start oral feeding was made by the attending neonatologist around 33

to 34 weeks PMA. We recorded the first ten minutes of breastfeeding or bottle-feeding while the infant was in a quiet, alert state ¹⁵. The infants were recorded in profile. At the time of the recording they did not suffer any intercurrent illness. The infants were fed either by one of the parents or, in some cases, by a nurse. The following details were registered for each recording: breastfeeding or bottle-feeding, whether the teat a regular one or a SpecialNeeds Feeder. This was included in the analyses. We also noted the type of nourishment: (mother's milk or a choice of 12 formulae (or a combination of two formulae). All these kinds of nourishments were allowed but we did not include them in the analyses. If possible, we noted the amount of cm³ the infants had consumed in two and thirty minutes, any change in their behavioural states during feeding, and whether there had been any choking, breathlessness, discolouring, or stress.

From 34 to 40 weeks PMA, we recorded the infants at weekly intervals and every 2 weeks from 40 to 50 weeks PMA (10 weeks post-term). At most we made twelve recordings per infant. Altogether we assessed 465 usable recordings of 49 infants (120 recordings in the SGA group and 345 recordings in the AGA group). Before term equivalent age there were 44 recordings in the SGA group and 168 in the AGA group. After term age there were 76 recordings in the SGA group and 177 in the AGA Group.

Analysis of sucking patterns

From the ten-minute recordings we selected the first two-minute episodes of feeding to assess the infant's sucking pattern with the NOMAS. The NOMAS is an often used, non-invasive observation instrument consisting of 28 items: 14 for assessing jaw movements and 14 for assessing tongue movements ^{8,9}. The instrument distinguishes during the first two-minute episodes of feeding three sucking patterns: a normal (mature) sucking pattern, a disorganised sucking pattern, and a dysfunctional sucking pattern. In case of a disorganised sucking pattern the coordination between sucking, swallowing and breathing is disrupted while the tongue and jaw movements are normal. In case of a dysfunctional sucking pattern abnormal jaw and tongue movements cause sucking to be impossible or inefficient ⁸. A dysfunctional sucking pattern is considered to be more abnormal than a disorganised sucking pattern.

In order to gain insight into the way preterm infants developed a normal sucking pattern, we also assessed the separate items during each two-minute episode. In addition, we distinguished between a slightly abnormal sucking pattern (only the item arrhythmical was scored) and a definitely abnormal sucking pattern (arrhythmical combined with other abnormal items, or a dysfunctional pattern).

Inter-rater and intra-observer reliability

Previously, we had found that the intra-rater agreement of the NOMAS was 'fair' to 'almost perfect', whereas the interrater agreement with respect to the diagnosis (normal, disorganised, dysfunctional) was 'moderate' to 'substantial' ⁹. For the purpose of this study two NOMAS assessors judged each recording independently from each other. These assessors were among twenty Dutch speech therapists who were certified NOMAS assessors. If two assessors were unable to reach consensus about a particular item during an episode, it was discussed with all the assessors. Finally, consensus was reached in all cases.

Longitudinal trajectories

The results of the repeated assessments of each infant (normal, disorganised, or dysfunctional) were graphically displayed on the time-axis, thus depicting individual developmental trajectories. In case of abnormal assessments, we also depicted details of the abnormalities found.

From the longitudinal trajectories we tried to determine when the sucking patterns had normalised. Since we were not aware of any study that had used the NOMAS in a longitudinal design, no benchmark existed to determine at what point in time an infant can be considered to have acquired a normal sucking pattern. Therefore, based on our findings in term infants ¹¹ we decided that an infant had acquired a normal sucking pattern, if at least two out of three consecutive episodes were diagnosed as 'normal'. The infant is said to have acquired a normal sucking pattern on the first of these three episodes.

Effectiveness of oral feeding

For each episode we determined whether feeding had been effective. The amount of intake was measured in case of bottle-feeding, and by weighing the infant before and after nursing in case of breast-feeding after two and thirty minutes. We noted whether the infants choked or whether they showed any signs of stress while feeding (colour change, nasal flaring, head turning, and extraneous movements). Finally, we noted whether the infant required additional tube feeding.

Relation between sucking patterns and clinical characteristics

We examined the developmental course of sucking patterns, age at normalisation of the sucking pattern, and specific abnormal patterns in relation to several relevant clinical characteristics. Regarding the infant's age when the sucking pattern normalised, we chose deliberately to investigate both at term equivalent age and at 10 weeks post-term age, which was the end of period under study. The clinical characteristics we examined included the variables mentioned in Table 1: gestational age, birth weight, the SD score for birth weight, gender, birth type, the Apgar scores at 1 and 5 minutes,

Table 1 The clinical characteristics of the study group. Data are given as median (range) or numbers (%) unless specified otherwise

	SGA preterms	AGA preterms
N	15	34
Male/female	12/3*	17/17
Gestational age, wk	31.4 (26.9 - 35.7)	31.9 (25.1 - 34.6)
Birth weight, g	995 (710-1813)*	1537 (569-2700)
SDS of birth weight (Z score)	-1.79 (-2.79 - -1.30)*	0.12 (-1.26 - 2.98)
Birth type		
Vaginal	2*	24
Caesarean Section	13*	10
Apgar 1 min.	7 (3 - 10)	7 (1 - 10)
Apgar 5 min.	9 (6 - 10)	8 (2 - 10)
The way of feeding		
Full breast feeding	N=1 (7%)	N=8 (24 %)
Both breast and bottle, >50% breast	N=2 (13%)	N=2 (6%)
Both breast and bottle, >50% bottle	N=3 (20%)	N=10 (29%)
Full bottle feeding	N=9 (60%)	N=14 (41%)
Respiratory data		
Number of infants on positive airway pressure	N=5 (33%)	N= 16 (47%)
Positive pressure ventilation > 28 days	N=1 (7%)	N=3 (8%)
Bronchopulmonary dysplasia (O2 dependency beyond 36 weeks PMA)	N=2 (14%)	N=1 (3%)
Ultrasound findings:		
Normal	N=6 (40%)	N=21 (62%)
GMH grade 1	N=1 (7%)	N=1 (3%)
GMH grade 2 - 4	none	none
PVL grade 1	N=4 (27%)	N= 12 (35%)
PVL grade 2 - 3	none	none
No ultrasound performed:	none	N=1 (3%)
NBRS	2 (0-9)	1 (0-9)

* Significant, p < .05

NBRS: Nursery Neurobiologic Risk Score 11

AGA: appropriate-for-gestational age

SDS: standard deviation score

SGA: small-for-gestational age

GMH : germinal matrix haemorrhage

PMA: postmenstrual age

PVL: periventricular leukomalacia

necessity and duration of positive airway pressure, the presence of BPD, the presence and degree of periventricular leukomalacia¹³ and germinal matrix haemorrhages (GMH)¹⁴, and the Nursery Neurobiologic Risk Score (NBRS) at discharge ¹² (Table 1, online).

Finally, we examined the relationship between the developmental course and the normalisation of sucking patterns and the necessity and duration of tube feeding.

Statistical analyses

The data were analysed with the statistical software package SPSS for Windows, version 16.0. The Chi² test, and where appropriate the Fisher's exact test were used to compare both groups for frequencies of normal and abnormal sucking patterns, both on the level of measurements and on the level of infants. We also calculated per child the percentage of specific categories relative to all measurements for that particular child. The Mann-Whitney U Test was used to evaluate whether these percentages differed between groups. The Mann-Whitney U Test was also used to evaluate whether the age at which the infant had developed a normal sucking pattern differed between groups. To test whether clinical variables influenced the rate of occurrence of normal and abnormal sucking patterns per infant, and the postmenstrual age at which the sucking pattern normalised, we used the Spearman's rank correlation test in case of ordinal or continuous clinical variables (gestational age, NBRS, SD score for birth weight, Apgar scores) and the Mann-Whitney U test in case of 2 nominal variables (birth type, need for ventilatory support, BPD, IVH and PVL status, gender, breast or bottle-feeding) in univariate analyses. Because perinatal and neonatal characteristics are likely to be interdependent, we performed a multivariate logistic regression analysis to investigate which factors contributed independently to developing a normal sucking pattern at term equivalent age and at 10 weeks post-term. Only factors identified by the univariate analysis (with $p < .10$) were included in the multivariate model. Throughout the analyses $p < .05$ was considered to be statistically significant.

Results

Analysis of the sucking patterns

The results of all the individual assessments of all the infants, grouped according to their gestational age, are shown in Figure 1a for SGA infants and in Figure 1b for AGA infants.

We found that 15 out of all 120 recordings (13%) for the SGA preterm and 133 out of 345 (38%) for the AGA preterm group were diagnosed 'normal' (Chi² = 27.8, $p < .001$). For the SGA group, 5 out of 120 recordings (4%) were

diagnosed 'dysfunctional', and 100 (83%) were diagnosed 'disorganised'. For the AGA group, 2 out of 345 recordings (0.6%) were diagnosed 'dysfunctional' and 210 out of 345 (61%) were diagnosed 'disorganised'. The frequencies of both dysfunctional and disorganised patterns were also significantly different between the AGA and SGA group: $\chi^2 = 9.9$, $p < .01$ for dysfunctional patterns, and $\chi^2 = 20.2$, $p < .001$ for disorganised patterns. Of the episodes that were diagnosed as 'disorganised' 187 were 'arrhythmical only', 58 (48%) in the SGA group, and 129 (37%) in the AGA group ($\chi^2 = 4.44$, $p < .05$). Definitely abnormal sucking patterns (all abnormal patterns except 'arrhythmical only') were more prevalent in the SGA group - 47 recordings (44%) in 14 infants - than in the AGA group - 83 recordings (24%) in 30 infants. ($\chi^2 = 10.1$, $p < .01$). Even though, given the fact that there are 28 items, one could possibly find many combinations of items in the diagnosis 'disorganised', it appeared that only a limited cluster of items were found. Apart from the item 'only arrhythmical', we scored only three other clusters, i.e. arrhythmical + unable to sustain, arrhythmical + incoordination, and arrhythmical + unable to sustain + incoordination. If the infant did not start sucking this was due to 'difficulty initiating movements'. If the infant did eventually start sucking during that same episode, it was possible that the infant would have an arrhythmic sucking pattern afterwards or a combination with one of the clusters. In that case, we scored the pattern that the infant showed while sucking.

The prevalence as percentage of the total measurements per child for each of these clusters, separately for the AGA and the SGA preterms, is shown in figure 2. The numbers of infants showing the normal and abnormal patterns are presented as well. Additionally, SGA preterms were hindered more by not being able to suck in a coordinated way (assessed as 'incoordination' in the NOMAS), than AGA preterms. This was expressed by stress signals, such as colour change, nasal flaring, head turning, extraneous (inappropriate) movements of the extremities (in 14, 12%, of the recordings in SGA preterms versus 14, 4%, of the recordings in AGA preterms, $\chi^2 = 9.1$, $p < .05$). On an infant level, 8 of 15 (53%) of SGA preterms showed 'incoordination' versus 10 of 34 (29%) AGA preterms (Fisher's exact, 2-sided, $p = 0.124$). In case of the SGA preterms, 1 of the 15 infants (7%) had a dysfunctional sucking pattern. It was diagnosed five times. In the case of the AGA preterm infants, this was the case in 2 out of 34 infants (6%). In both infants it was seen only once. Altogether, there were seven episodes (2%) where minimal jaw excursions and a retracted tongue were seen repeatedly. The percentage per child of clusters including 'incoordination' and dysfunctional sucking were significantly higher in SGA preterms than in AGA preterms (median 11% [0-63] versus 0% [0-40], Mann Whitney U test, $p < .05$). Regarding the way of feeding, many infants received breastfeeding as well as bottle-feeding (Table 1). Due to logistic reasons, the mother was not

Figure 1a The maturation of sucking patterns in sGA preterm infants The results of the repeated assessments of each infant were horizontally displayed on the time axis, depicting individual developmental trajectories. The children were vertically displayed according to increasing gestational age. The results of the individual measurements are shown in each box as normal, dysfunctional, and disorganized (arrhythmic + unable to sustain + incoordination sucking pattern, arrhythmic + incoordination sucking pattern, and difficulty initiating movements).

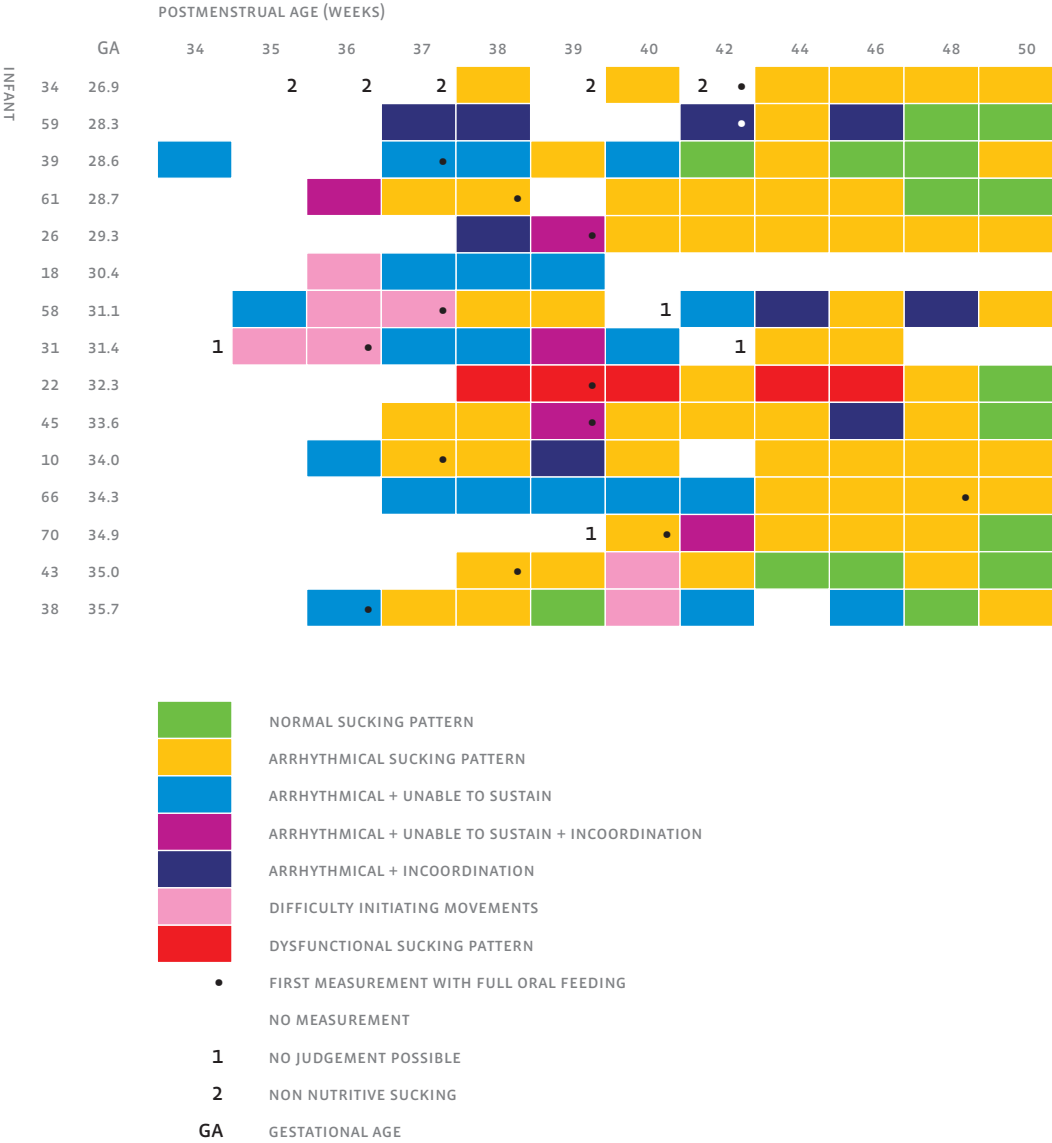


Table 2 Postmenstrual age (PMA) at which sGA and AGA preterm infants had a normal sucking pattern for the first time.

	Before term age (≤ 40 weeks' PMA)	Between 40 and 50 weeks' PMA	At 48-50 weeks' PMA the infant did not suck normally	Not measured at 48-50 weeks' PMA	Total
AGA Preterms	13	15	6	3*	34
SGA Preterms		7	6	2	15
Total	13	22	12	5*	49

* Included were 3 AGA children who all had normal sucking patterns before term

PMA: post-menstrual age

Chi² for trend, $p < 0.05$

Table 3 Effectiveness of feeding of sGA and AGA preterms. Data are given as median (range).

	sGA preterms	AGA preterms
N	14 ^a	34
Week of normal sucking pattern	50 (42 - >50)*	44 (34 - >50)
Week of independency of tube feeding	38.5 (36 - 48)*	36 (34 - >50)

* Mann-Whitney U test, $p < .05$

a Data lacking of one infant

AGA: appropriate-for-gestational age

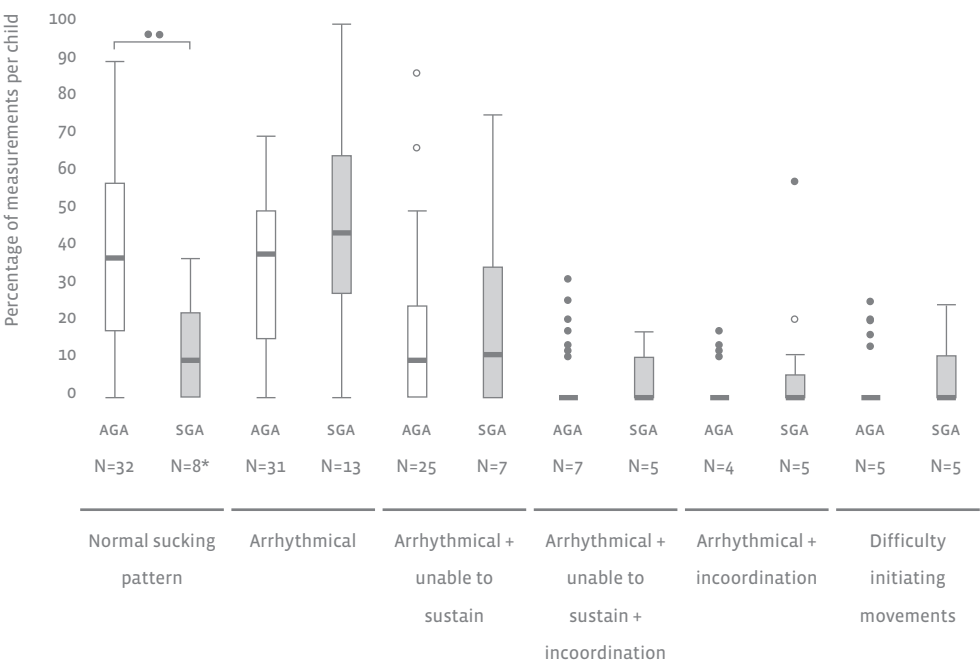
SGA: small-for-gestational age

always available to breastfed the baby. A vast majority of infants received most of their feeding by bottle, 12 of 15 infants in the sGA group (80%), and 24 of 34 infants in the AGA group (71%). The distribution of breast and bottle feeding was not different between groups (Table 1). Only one AGA preterm infant (infant nr 62) was fed during 5 measurements with a SpecialNeed feeder. The way of feeding, whether by bottle or by breast did not influence the occurrence of normal, disorganized, and dysfunctional sucking patterns (Figure 3a and 3b).

Longitudinal trajectories

Individual developmental trajectories of sucking patterns can be derived from Figure 1a and 1b. These findings are summarised in Table 2. The sGA preterm children needed more time to acquire a normal sucking pattern than

Figure 2 Median percentages of rate of occurrence of normal and abnormal measurements per child, in each group. The abnormal measurements were grouped according to the separate disorganized categories. The numbers of infants who had this particular pattern on one or more occasions in each group is provided at the bottom of the figure. Significant differences between the percentages and number of children were marked - $p<.01$ and - - $p<.001$.



the AGA preterms (median 48 weeks versus 42 weeks, Mann-Whitney U test $p=.002$). At term equivalent age, none of the 15 SGA preterms and 13 out of the 34 AGA preterms (38%) showed a normal sucking pattern ($\chi^2 = 5.5, p<.05$). At 48 to 50 weeks PMA (8 to 10 weeks post-term), 7 out of 13 SGA preterms (54%) and 25 out of 31 AGA preterms (81%) had acquired a normal sucking pattern (Table 2, $\chi^2 = 3.3, p=.064$). At that age, data on 5 infants are lacking. From birth up to 50 weeks PMA the sucking patterns of the SGA preterms developed from definitely to slightly abnormal. At 8 to 10 weeks post-term the 6 infants that still had not acquired a normal sucking pattern all had the slightest abnormal form of a disorganised sucking pattern, i.e. ‘arrhythmical only’.

In the case of the AGA preterms, 13 out of 34 infants (38%) had acquired a normal sucking pattern prior to term age. Three of them were not

Figure 3a The use of bottle feeding (marked B) and formula feeding (marked F) for each measurement in SGA preterm infants, in relation to normal, disorganized or dysfunctional sucking patterns.



Figure 3b The use of bottle feeding (marked B) and formula feeding (marked F) for each measurement in AGA preterm infants, in relation to normal, disorganized or dysfunctional sucking patterns.

		POSTMENSTRUAL AGE (WEEKS)												
INFANT	GA	34	35	36	37	38	39	40	42	44	46	48	50	
8	25.1	F	F	F	F	• F	F	F		F	F	F		
69	26.0			B	B	B	B		F	F	F	F	F	
40	26.6	B			• B	B	B	B	B	B	B	B	B	
65	27.0	1	F	B	B	B	B	B	• F	F	F	F	F	
62	27.3				F	F	F	• F	F	F	F	F	F	
55	27.9	B	B	• F	F	F	F	F	F	F	F	F	F	
13	28.3	B	• B		B	B	B		B	B	B	B		
63	28.7		• F	F	F	F	F	F	F	F	F	F	F	
48	29.1	B	B	F	• F	F	F	F	F	F	F	F	F	
49	29.1		B	F	• F	F	F	F	F	F	F	F	F	
27	29.3					F	F	F	• F	F	F	F	F	
50	29.4	B	F	• B	B	B	B	B	B	B	B	B	B	
51	29.4	B	F	• 2	B	B	B	B	B	B	B	B	B	
35	29.7	F	F		F	• F	F	F	F	F	F	F		
15	29.9			• B	B	B	B	B	B	B	B	B	B	
7	31.3		F	F	• F	F			F	F		F	F	
11	31.6		2	B	• B	1	B	1	F	F	F	F	F	
29	32.3	B	B	• B	1	F	F	F	F	F	F	F	F	
37	32.3	• B	B	2	B	1	B	B	2	2	2	2	2	
41	32.4		• F	F	F	F	F	F	F	F	F	F	F	
28	32.9	1	B	• B	B	F	F	F	F	F	F	F	F	
3	33.0	B	B	B	• B	B	B	B	B	B			B	
56	33.0	B	B	• B	B	B	B	B	B	B	B	B	B	
53	33.1	F	F	• F	F	F	F	F	F	F	F	F	F	
52	33.1	F	F	• F	F	F	F	F	F	F	F	F	F	
54	33.1	F	F	• F	F	F	F	F	F	F	F	F	F	
44	33.6		F	• F	F	F	F	F	F	F	F	F	F	
9	33.7		B	B	B	B	B	B	B	B	B	B	B	
14	33.9	• B	B	B	B	F	F	F	F	F	F	F	F	
30	33.9		2	• F	F	F	F	F	F	F	F	F	F	
16	34.1		F	F	• F	F	F	F						
17	34.1	F	F	F	• F	F	F	F						
57	34.3		B	• F	F	F	F	F	F	F	F		F	
19	34.6		B	B	• B	B		B	B	B	B	B	B	

measured after term age. Out of these 13 infants there were 9 (26%) infants that initially had a definitely abnormal sucking pattern for one to six weeks. One half of these infants acquired a normal sucking pattern following a slightly disorganised sucking pattern. Of the 15 AGA preterms (44%) that only developed a normal sucking pattern between 40 and 50 weeks PMA, we noticed that 12 still made short sucking bursts up to the age of 44 to 46 weeks PMA. This fits in with the slightest abnormal form of sucking, i.e. an 'arrhythmical only' sucking pattern. Three out of these 15 infants showed a more abnormal sucking pattern during this period; apart from the fact that the bursts of sucking were too short, they were also unable to sustain it. Six AGA preterms (18%) had not acquired a normal sucking pattern at 8 to 10 weeks post term. This was expressed differently in the 6 infants: 2 remained definitely abnormal, the other 4 showed a slightly abnormal sucking pattern on most of the episodes from term age.

Effectiveness of oral feeding

All fifteen SGA preterm infants and 33 out of the 34 (97%) AGA preterms were feeding orally completely at 10 weeks post-term (Table 3).

A total of six infants (13%, one unknown), divided over three out of 14 SGA preterms (21%) and three out of 34 AGA preterms (9%) still received supplemental tube feeding beyond 40 weeks post term age, and one AGA preterm infant was still partially tube-fed at 10 weeks post-term. SGA preterms depended on supplemental tube feeding longer than AGA preterms (Mann Whitney U-test, $p = .002$) (Table 3). AGA preterm infants that had acquired a normal sucking pattern before the age of 10 weeks post-term, required tube feeding less long (Mann Whitney U-test, $p < .0001$). In the AGA group, the age at which tube feeding was no longer required correlated with the age at which the infant acquired a normal sucking pattern (Spearman's $\rho = 0.714$, $p < .0001$). This was not the case for the SGA group.

The relation between the sucking patterns and the clinical characteristics. Clinical characteristics of both groups differed regarding the distribution of both sexes, with the SGA group having relatively more males (Fisher's exact, $p = 0.064$). There were 3 infants with mild BPD. Two of them were SGA, and needed supplemental oxygen until 37 and 38 weeks PMA; one infant was AGA, and needed supplemental oxygen until just beyond 36 weeks PMA.

The age at which AGA preterm infants acquired normal sucking not only correlated strongly with gestational age (Spearman's $\rho = -0.691$, $p < .01$), but also with birth weight (Spearman's $\rho = -0.764$, $p < .01$) and with the NBRS (Spearman's $\rho = 0.611$, $p < .01$). We did not find such correlations for the SGA preterm infants.

Clinical characteristics are likely to be interdependent. Therefore, we performed first a univariate logistic regression to determine which factors

were associated with a normal sucking pattern at term equivalent age as well as at 10 weeks post-term. At term equivalent age, the factors BPD, IVH and PVL status, breast- or bottle-feeding, Apgar score at 5 minutes, need for ventilatory support, and gender were not significant ($p>0.10$), whereas gestational age, SD score for birth weight, birth type and NBRs were with $p < 0.10$. Next we performed a multivariate logistic regression analysis for the total group to determine which factors contributed independently to whether the infant reached a normal sucking pattern. For abnormal sucking at term age we entered gestational age, SD score for birth weight, birth type, and NBRs in the model. Only NBRs (OR: 0.24 [95% confidence interval (CI): 0.09-0.70]; $p=0.009$) and SD score for birth weight (OR: 2.2 [95% CI: 0.98-5.1]; $p=0.056$) remained in the model, which explained 51.2% of the variance of normal and abnormal sucking patterns at term. The same procedure was followed for the associations found at 8 to 10 weeks post-term. Now the factors BPD, IVH and PVL status, breast- or bottle-feeding, Apgar score at 5 minutes, need for ventilatory support, and gender were not significant ($p>0.10$). The following variables were entered as predictors: gestational age, SD score for birth weight, birth type, and NBRs. Only gestational age (OR: 1.5 [95% CI: 1.1-2.0]; $p=0.013$) and SD score for birth weight (OR: 2.8 [95% CI: 1.3- 6.4]; $p=0.012$) remained in the model. It now explained 35.0% of the variance of normal and abnormal sucking patterns at 8 to 10 weeks post term.

Discussion

This study demonstrates that the development of sucking patterns in SGA preterm infants was slower than in AGA preterms from when they started feeding orally during the first 10 weeks post-term. It also took a different developmental course. In the SGA group we diagnosed a dysfunctional and disorganized, uncoordinated, sucking pattern more often. Particularly prior to term age, the SGA infants were hindered by a lack of coordination between sucking, breathing and swallowing. A substantial part of the AGA preterms, however, also only acquired normal sucking after having reached term age. We stress that an abnormal sucking pattern did not necessarily mean that the infant was unable to suck effectively. Almost all preterm infants were fed orally completely even though they still had abnormal sucking patterns. This improved towards the end of the period under study. At the age of 10 weeks post-term, one infant was still supplementary tube-fed. This infant had an abnormal sucking pattern: it was unable to sustain sucking and had difficulty coordinating breathing with sucking and swallowing. Therefore, he needed some extra intake by tube.

Our study, which spanned the first 10 weeks post-term, cannot confirm the assumption that SGA preterm infants mature more rapidly ¹⁷.

After they had reached term age, we indeed found that sucking patterns normalised, but a substantial number of SGA preterms were hindered longer by abnormal sucking patterns. SGA preterm infants are at risk for an impaired postnatal neurological condition and an impaired neurodevelopmental outcome ^{6, 17-19}. It is conceivable that the abnormalities we found in the development of their sucking patterns could be related to their abnormal neurological condition. Another possibility is that their developmental course was delayed rather than abnormal and that eventually the majority of SGA preterms would start sucking normally, but only after they had reached the age of 10 weeks post-term, i.e. outside the scope of our study. The development of normal and abnormal general movements (GMs) too, is slower in some SGA preterm infants than is the case for AGA preterm infants ²⁰.

In this study we found several differences in the development of sucking between SGA preterms and AGA preterms. Firstly, we found a dysfunctional sucking pattern in SGA preterms more often. This sucking pattern refers to the interruption of the feeding process by abnormal movements of the tongue and jaw, and according to Palmer ⁸, it is caused by abnormal oral facial structures, or it can be due to abnormal oral muscle tone ²¹. Because oral facial anomalies were excluded, we presumed that abnormal oral muscle tone might have caused a dysfunctional sucking pattern. The tone of the facial and intra-oral muscles are dependent on the function of the cranial nerves, therefore, a dysfunctional sucking pattern could point towards neurological dysfunction ².

A second finding was that SGA preterms, especially prior to term age, were often hindered by a definitely abnormal, disorganised sucking pattern, that is expressed in uncoordinated sucking, swallowing and breathing. The infant was unable to sustain a sucking pattern for two minutes due to its inability to coordinate breathing with sucking and swallowing, which was interrupted because of respiratory incompetence. This may result in oxygen desaturation, and stress signals such as nasal flaring, and head bobbing ^{21, 22}. Often the infant was fatigued because of energy depletion. Respiratory difficulties and disorganization of the central nervous system play a key role in exacerbating these problems ²². It is, therefore, most likely that abnormal sucking patterns indicate neurological abnormalities in the SGA preterms. A physiologically intact and functioning central nervous system may be one of the crucial elements for an infant to successfully latch on and start feeding ²³. Our study indicated that SGA preterms have more difficulty organising their neurobehavioral functioning than do AGA preterms.

We identified several perinatal factors that were predictive of achieving a normal sucking pattern at term equivalent age and at 10 weeks post-term in both groups. Independent predictors were SD score for birth weight and gestational age. This means that SGA preterms and extreme

preterm infants are at risk for achieving a normal sucking pattern at a later age and for developing an abnormal sucking pattern. In the case of these infants we recommend checking the necessary preconditions to start oral feeding carefully and to allow an infant to learn to drink only while its physiological parameters and neurobehavioral functioning are carefully monitored.

This study is strong for two reasons. Firstly, due to its longitudinal design. We have followed the development of sucking and sucking patterns during the entire neonatal period. Most studies of sucking behaviour and sucking patterns in preterm infants are based on one or two recordings, or during a short period of time. In our study we recorded and examined preterm infants from two to seven days after they started feeding orally until they reached 50 weeks PMA. Secondly, our study focussed on the sucking development of the preterm SGA infant. To the best of our knowledge, no other studies to date have described the development of sucking and sucking patterns of SGA preterm infants. In addition, our study included both breastfeeding and bottle-feeding infants and during recording there were no interventions with regards to feeding.

There were some limitations to this study. We described the development of sucking up to the age of 10 weeks post-term only. Approximately 13% of the total group still received supplemental tube feeding at more than 40 weeks post term age. This seems a rather high percentage, and is counter to experience in that virtually all preterm infants, whether SGA or AGA, are discharged home on full oral feeds a few weeks before term. Prolonged additional tube-feeding may partially be explained by the clinical characteristics of our group, such as e.g. BPD. It may also reflect local feeding policy, stressing the prerequisite for sufficient oral intake, if deemed necessary by additional tube feeding. Being merely a twin-centre study, caution should be taken when generalising our results to other centres. Although it was rather a heterogeneous group in which only a few infants were artificially ventilated, we did nonetheless find a number of essential differences in the development of sucking between SGA and AGA preterm infants. The disproportionate number of males in the SGA group could have biased the results, since males often attain feeding milestones a little later than females. However, logistic regression analysis did not reveal male gender as an additional risk factor for abnormal sucking patterns, whereas the degree of growth restriction did. Further research will have to reveal whether our findings can be generalised to all SGA preterms.

Our study may have implications for the daily feeding practice of preterms, particularly SGA preterm infants. Sucking problems in SGA preterms may recover as a result of normal development. Sometimes, however, these problems may persist for a longer period of time which then interferes

with the need for catch-up growth to overcome the growth retardation in these infants.⁷ Our finding that only half of the SGA preterms had acquired a normal sucking pattern at 8 to 10 weeks post-term, indicated that when taking care that SGA preterms grow sufficiently, learning to drink should be carefully guided. In the case of this group of infants, the point is not that the infant should be able to feed orally as quickly as possible. On the one hand, policy should be aimed at ensuring that the infant's intake by means of tube feeding is sufficient to guarantee growth while, on the other hand, by allowing the infant to practise oral feeding, it is given both the time and opportunity to develop a normal sucking pattern. Insight into the development of sucking and swallowing may contribute to decisions concerning when to start oral feeding in relation to the development of sucking in this group of infants. If, as far as starting and scheduling oral feeding is concerned, the individual infant and the development of its sucking behaviour are monitored carefully, it will quickly become clear whether it has a dysfunctional sucking pattern. This is important, because a dysfunctional sucking pattern is characterized by abnormal tongue and jaw movements, which requires assessment by a speech therapist. Together with the paediatric nurse, they can draw up a plan of intervention.

Conclusion

SGA preterms developed a normal sucking pattern later than AGA preterms. They had a dysfunctional and disorganized, uncoordinated sucking pattern more often and, prior to term age, they had more difficulty coordinating breathing with sucking and swallowing. But AGA preterms too needed time after having reached term age to develop a normal sucking pattern. A longer gestational age and higher SD score for birth weight were associated with acquiring a normal sucking pattern at 8 to 10 weeks post-term.

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